Four years study of Large Particles (>0.15 mm) vertical distribution (0-1000 m) in the NW Mediterranean in relation to hydrology, phytoplankton and vertical flux.

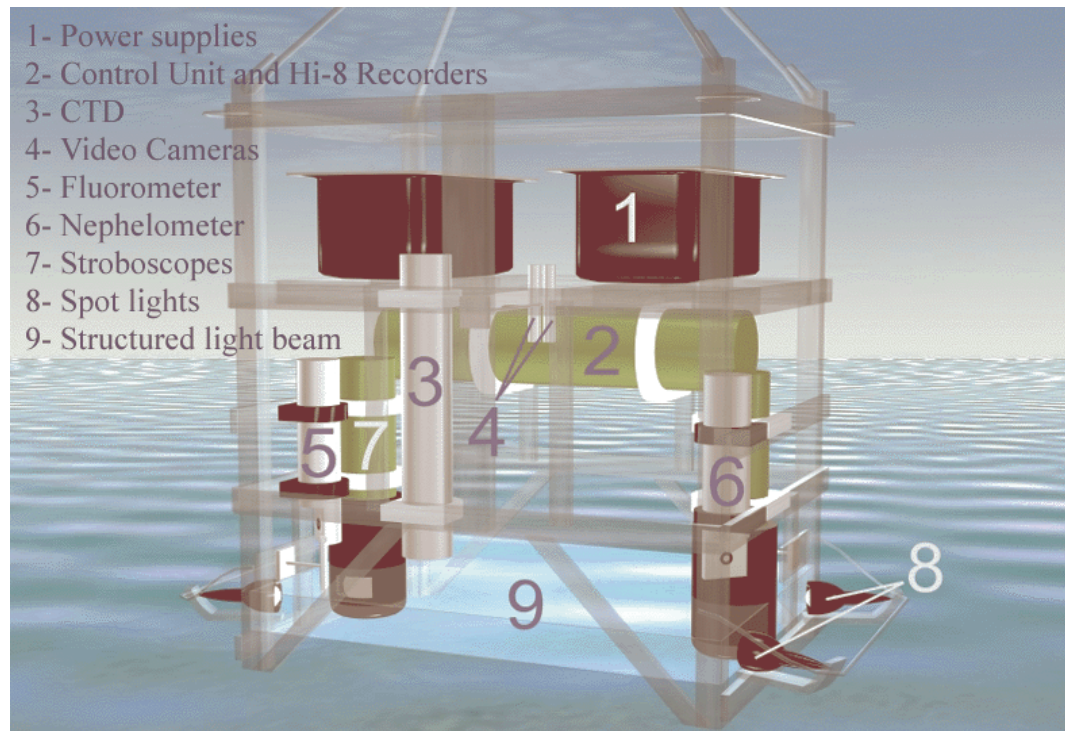Stemmann Lars [a,b,*], Gorsky Gabriel[b] , Marty Jean-Claude[b], Picheral Marc[b], Miquel Juan-Carlos[c]

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Notice describing the UVP methodology and the data set contained in the CDROM

and discussed in the paper.

The Underwater Video Profiler (UVP)

The UVP is a multi-instrumental array constructed in the Laboratoire d'Océanographie de Villefranche sur mer, France. This non-disturbing technique is used to investigate :

1) the abundance and size distribution of particles in the 0-1000 m water column (0-2800 m working range can be attained with slight modifications of the existing equipment).

2) the vertical distribution of zooplankton (mostly macro-zooplankton).

1- Power supplies
2- Control Unit and Hi-8 Recorders
3- CTD
4- Video Cameras
5- Fluorometer
6- Nephelometer
7- Stroboscopes
8- Spot lights
9- Structured light beam

Figure 1 : The Underwater Video Profiler (model III)

The UVP is deployed vertically and is composed of a waterproof, multi-instrument array for *in situ* image and environmental data acquisition and of a system allowing the analysis of images and the treatment of data. 4 models were constructed and the size of particles detected and treated by these instruments range from 0,1 mm to 10 cm.

All models are autonomous and can be lowered on any hydrological cable. The UVP model II has been used at DYFAMED station between 1992-96 and the method has been described in Gorsky et al. (1992) and Stemmann et al. (2000). Since 1996 two additional versions have been developed and are described below.

The UVP model III (Gorsky et al., 2000) and IV (Figure 1) are vertically lowered instruments mounted on a galvanized steel frame (1.1 x 0.9 x 1.25 m). The lighting is based on two 54W Chadwick Helmuth stroboscopes (Figure 1-7). Two stainless steel mirrors spread the light beams into a structured 10 cm thick slab (Figure 1-9). The strobes are synchronized with two Exavision XC 644 black-and-white CCD video cameras with 12 and 6 mm C-mount lenses (Figure 1-4). The cameras are positioned perpendicularly to the light slab and only illuminated particles in dark background are recorded. The short flash duration (pulse duration = 30 µs) allows a fast lowering speed (up to 1.5 m/s) without the deterioration of image quality. The illuminated particles are recorded simultaneously, into two Hi8 recorders in the case of model III or are digitized in real time and recorded into hard discs fitted to a watertight cylinder (Figure 1-2).

All the models were calibrated in a dark test tank filled with 3 m^3 filtered (0.8 µm) sea water. The brightness measured in the test tank was similar to that in the aphotic layers. A calibration grid, placed at different depths of the light slab, was used to estimate the recorded water volume.

The thickness of the model II parallel light beam was 1.5 cm and particles were recorded in a volume of 0.28 liters. Models III and IV illuminate a larger volume of water : 131.6 x 125 x 95 mm representing 1.33 liter, and 288.5 x 264.7 x 99.25 mm representing 6.51 liters are recorded by the 12 mm and the 6 mm cameras respectively.

The pixel/mm relationship for the model II was obtained by the analysis of biological particles (>50 µm) injected into the field of view of the cameras. Each particle was measured prior to its use with a stereomicroscope (Figure 2). Latex spheres of 80 µm in diameter constituted the minimum detected size but they were not used for the calculation of the correction factor. Biological particles larger than 150 µm in equivalent spherical diameter (ESD) could be reliably counted. The best fit to the data points (figure below) was a power function, and the parameters were calculated using an optimisation method. Scattering of residuals was high but they were normally distributed (Kolmogorov test for goodness P>0.01) and independent (Durbin and Watson test on residuals, Dobs>Dc2 at a=0.01).

For UVP model III, the results indicate that the tested configuration can detect 280 µm-sized particles and can reliably measure particles larger than 460 µm in diameter.
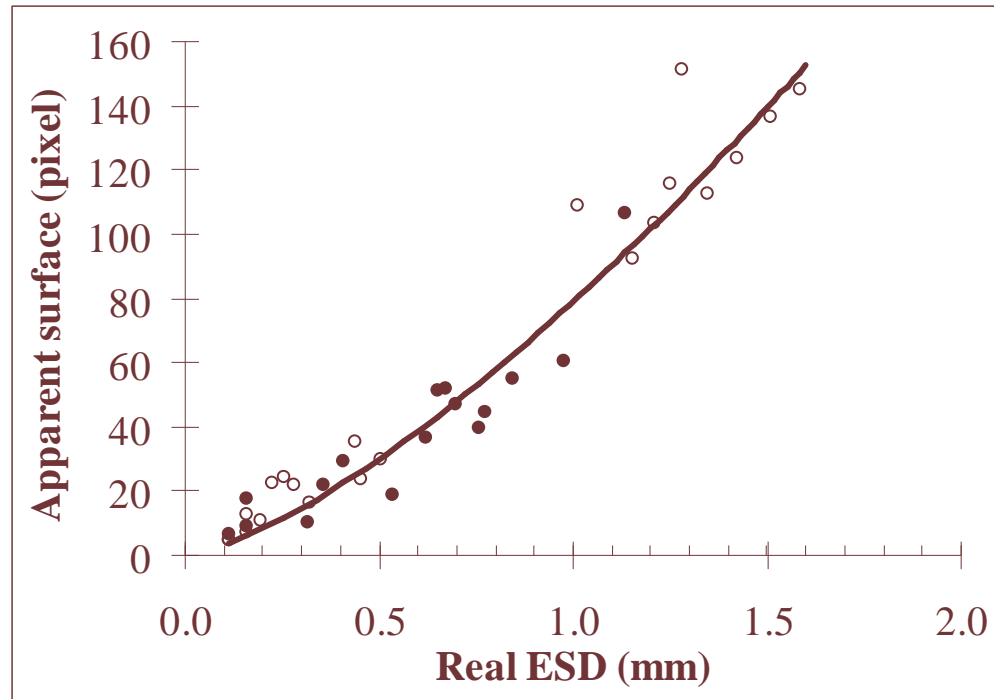
Figure 2: Relation between particle ESD (mm) measured using a stereomicroscope and it's apparent surface after digitization (in pixels) for UVP model II. Two types of objects have been used (open square for the dense particles and filled squares for others).

Equations used for this work

$$Sm = a * Sp^{b}$$

where a= 0.00139 and b=1.430 (according to the regression) and

where Sm is the area (mm^2) and Sp is the number of activated pixels after the digitization

$$ESD = 2 * \sqrt{\frac{Sm}{\pi}}$$

ESD : Equivalent spherical diameter (mm)

$$V = \frac{4}{3} * \pi * \left(\frac{ESD}{2}\right)^{3}$$

V : Volume in mm^3

$$PsT = 8.8 * ESD^{1.125}$$

PsT :Dry Weight in microgramme (Alldredge et Gotschalk, 1988)

Depth, temperature and conductivity data are acquired using a Seabird Seacat 19 CTD probe fixed on the UVP frame (with fluorometer and nephelometer from Chelsea Instruments Ltd.). The system is powered by four 24V batteries and is piloted by a microprocessor. The data acquisition can be time or depth related and programmed prior to the immersion. Daylight brightness can interfere with the imaging of particles in the upper 20-30 meters. This problem can be minimized using red filtered illumination.

A complete dataset can be obtained onboard shortly after the deployment of the UVP. The data acquisition is performed during the descent and the simplified data treatment during the ascent (in model IV). Thus, once on the deck, data from different sensors are transferred to the bench top computer, merged and the relation between the different biogeochemical parameters visualized (Animation 1).

Animation 1 : Distribution of particles size classes along a section in function of the fluorescence and the density. (Click to start and to freeze the animation)

Bodies of zooplankton might be recorded and considered as particles. We analyzed and compared zooplankton profiles with profiles of particles at the studied site (Stemmann et al. 2000). The number of living organisms was found to be one or two orders of magnitude lower than that of large non-living particles.

2-   Four 100 W spotlights can be used instead of the stroboscopes for continuous observations of a larger non structured water volume (Figure 1-8). In this case the lowering speed is slower. The UVP is well adapted to count and measure fragile aggregates such as marine snow as well as delicate zooplankton (Animation 2). For reliable assessment of macrozooplankton, a programmed repetitive profiling option is available.

Animation 2 : Siphonophore, Tomopteris sp., chaetognath and larvacean recorded by the UVP.

Data processing

The UVP has two important features: a) it does not disturb the recorded particles or organisms and b) it allows quick data retrieval and processing. Processing of images obtained by the UVP in the structured light beam is automated. In the digital model (IV), every image of the two video cameras (0-1000 m profile at a 1m/s lowering speed and at the acquisition rate of 12 images/s) is digitized using a Matrox frame grabber and stored on the hard discs. During the ascent, the particles are detected, enumerated and the chosen physical attributes extracted. Data are stored in an ASCII file and can be combined with the associated CTD, fluorometer and nephelometer data immediately after the recovery of the UVP. Onboard the stored images can be reprocessed for more attributes extraction.

The Hi8 tapes from the analogic models (II and III) are digitized onboard at normal speed and without compression and images are stored and treated following the procedure described above.

A Matlab program (MATLAB, Scientific Software) is used for further treatment of the data.

The Underwater Video Profiler is commercialized by METAL PROCESS Ltd.
http:\www.metalprocess.com

References

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Acknowledgements

Large Particles data contained in the CDROM

We did not include in the CDROM all the size spectra, instead we provide synthetic data on large particles distribution for each sampling date. The data have been averaged over 10 meters. Each file corresponds to a sampling date and the name of the file stand for the date of the sampling Ddd/mm/yy (for example D120395 stands for a sampling at DYFAMED on the 12th of March 1995).

The order of the column in each file is :

Col 1 : Depth (m)
Col 2 : Abundance (# / l)
Col 3 : Mean length (mm)
Col 4 : Mean projected area (mm2)
Col 5 : Mean ESD (mm)
Col 6 : Total volume (ppm)
Col 7 : Total Dry weight (µg / l)

Sampling periods for LP, phytoplankton and sediment trap at DYFAMED between 1992 and 96. The * marks period for which a CTD transect was completed.

Date (UVP)		
13/01/92*	16/10/93	12/05/95
26/03/92*	09/11/93*	16/05/95
26/05/92*	10/12/93*	26/05/95
29/06/92	12/01/94*	31/05/95
07/07/92*	03/02/94	22/07/95*
15/09/92*	08/03/94*	
13/10/92	08/04/94*	29/11/95
19/11/92*	04/05/94*	03/12/95
16/12/92	09/05/94*	09/02/96*
27/01/93*	06/06/94*	02/04/96*
19/02/93	30/06/94*	18/06/96
10/03/93*	22/08/94*	
23/03/93	17/10/94*	
21/04/93*	24/11/94*	
17/05/93*	03/12/94*	
24/05/93*	15/01/95*	
08/07/93	12/02/95*	
21/07/93*	06/03/95*	
08/09/93*	03/04/95*	
05/10/93*	12/04/95*	